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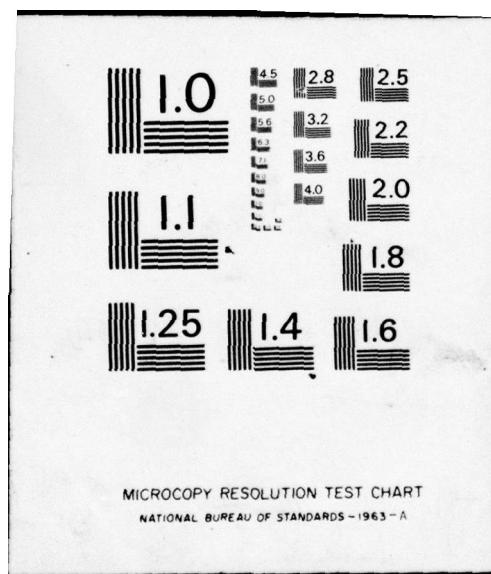
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AIRCREW PROTECTIVE CLOTHING & DEVICES SYSTEM (FIGHTER/ATTACK AIRCRAFT)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) <i>A study was conducted to portray the major mission profiles in which the Fighter/Attack community is engaged and by so doing, to identify the problem areas associated with the current inventory of Fighter/Attack Aircrew Protective Equipment toward fulfilling the requirements of these missions. The ultimate objective of this effort is to provide a sound basis from which a series of separate but coordinated engineering developments will be conducted to provide a new generation of mission-oriented protective</i>			

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20. systems for the Fighter/Attack community. The net effect of this program will be to enhance the inflight performance and effectiveness of all Fighter/Attack aircrewmen with little or no sacrifice to their safety in the event of an emergency situation.

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S U M M A R Y

This report has been prepared in support of Advanced Development Objective (ADO) 45-67, Aircrew Protective Clothing and Devices Systems. In response to the objectives of the ADO, a study was conducted to identify profiles of the major missions which the Fighter/Attack community conducts and, by so doing, to identify how the current inventory of Fighter/Attack aviator protective equipment reduces the effectiveness of these missions.

The ultimate objective of this effort is to provide a sound basis from which a series of separate, but coordinated, engineering developments, will be conducted to provide a new generation of integrated, mission-specific protective systems for the Fighter/Attack community.

The data from this study were derived from direct, on-site visits and individual interviews with the aviators and associated technical support personnel in each of the various type squadrons. From this, key problems concerning the current generation of protective equipment systems were identified within their operational context.

Many of the problems of current Fighter/Attack aviator protective equipment are amenable to solution and/or improvement by current state-of-the-art technology.

The intended effect of this program is to enhance the inflight performance and effectiveness of the Fighter/Attack aviators with no sacrifice of their safety in the event of an emergency situation.

P R E F A C E

The information contained in this report was derived from extensive observations, discussions, and data reviews. There were conflicting data and divergence of opinion concerning general equipment employment problems, and specific applications within the broad envelope of Fighter/Attack operations.

In order to sort out and present this information in the most rational and systematic form, extensive analysis and refinement of the data for each equipment system category and functional capability was required.

Final analyses and resolution of these data were guided by priority factors reflecting frequency of occurrence and degree of probable impact on aviator performance upon mission effectiveness.

I N T R O D U C T I O N

BACKGROUND

Naval aviators are currently equipped with a variety of protective clothing and systems which are intended to protect them against a range of operational hazards which may be encountered through the mission profile.

Each item of the aviator's protective equipment may be considered generally adequate when assessed on an individual level. However, when this equipment is worn and utilized collectively during the routine performance of a mission, the aviator experiences significant penalties in thermal comfort and restriction of mobility, because of the weight, bulk, and non-integration of the equipment.

In addition to this, some equipment, designed to provide protection to an aviator against certain hazards which may occur in his mission envelope, has been imposed upon other aviators who have different protection requirements in their particular mission envelope. The primary cause for this has been due to economy and standardization. The net outcome of all this has been a number of adverse effects on the aviator's performance, endurance and efficiency which have cumulatively degraded overall mission effectiveness. This situation has been compounded by the aviator making unauthorized, but sometimes necessary, modifications to his equipment configuration, or even avoiding the use of the equipment entirely, to "self-enhance" his effectiveness during non-emergency situations. Using the rationale that "certain hazards or emergency situations will not confront me", many aviators are then unprepared when the unexpected does occur. In certain instances, authorization for deviation has been granted, but carries with it the obvious adverse technical consequences.

ADO 45-67 is an advanced development program which will provide each aviator with a mission-specific, functionally integrated, system of protective clothing and equipment which ensures protection against natural and induced environmental hazards encountered during routine, combat, and emergency flight operations including escape, survival and rescue following loss of the aircraft.

The mission-specific concept for this advanced development was originated at the Naval Air Development Center (NAVAIRDEVCEN) as a result of previous efforts during the 1968-1970 period.

A Technical Development Plan (TDP) for this program was issued in April 1972. The ADO 45-67 Advanced Development Program, established by the Chief of Naval Operations (CNO), was initiated in July 1973 under the management of the Naval Air Systems Command (AIR-340B). This development effort, which began in Fiscal Year 1974, will extend through Fiscal Year 1980.

To provide a total systems approach to achieve the full objectives of this program, the program was expanded in FY-74 to include development of the related aircraft life support and escape sub-systems as well as the personal items of equipment typically worn by the aviator.

RATIONALE

The investigation and definition of problems associated with the use and

employment of aviator protective clothing and equipment systems must confront two separate but related factors inherent to protective clothing and equipment systems. The first factor pertains to the engineering design and construction of a given item of equipment in a protective system. Due to the fact that the equipment must provide its intended function under a wide variety of environments and conditions over extended periods of time, it must be constructed for ruggedness, durability, and reliability. The second factor pertains to aviator utilization in terms of comfort, fit, and general acceptability, e.g., preference and style. This factor is obviously a composite of many individual/subjective variables which can vary between users, over time, and under different conditions.

In essence, the first factor is a composite of the objective, and the second factor is a composite of the subjective. Accordingly, the subjective is inherently more difficult to specify with precision and clarity. The results of this report and the findings contained herein reflect this limitation.

The initial objective of this study was to define aircraft mission requirements for protective systems, leaving the fulfillment of these requirements to the cognizant design engineers. However, there are definite limitations to this approach due to lack of adequate quantitative physiological data for such factors as performance degradation of mental and physical functioning as a result of human reaction to impact forces, various "G" loads, heat stress, noise and vibration over various time periods and mission cycles acting singly or in varying combinations throughout a mission cycle. This problem has been exceedingly difficult to resolve. To attempt to collect such extensive data would entail an enormous undertaking in money, time, and manpower. These resources were not available for this program. This fact necessarily limits the approach taken in analyzing the functional adequacy of current protective equipment and systems and design improvements.

It is important to stress that protective equipment redevelopment should not necessarily be limited to the production of single purpose equipment. The information contained in this report can be used to effect development of consolidated systems wherein modular integration can provide multi-function protective systems. For example, the standard flight suit could be designed to incorporate flotation function, thermal cooling, and anti-exposure as well as "G" protection as a single integrated system. Due to recent developments in materials and fabrication technology as well as certain advances in other fields of engineering, the feasibility and desirability of this approach is now at hand. These factors coupled with the design objective of ADO 45-67 (Aircrew Protective Clothing and Devices Systems) for modular, integrated, multi-function systems can provide the driving force for the realization of new approaches in the design of life support protective systems for present and future man/aircraft systems.

APPROACH

The information contained in this report was obtained directly from the various operational fighter/attack squadrons. The investigator conducted direct, on-site visits with the aircraft squadrons. Whenever possible and

practical, the investigator observed the aviator's functions and tasks during suit-up, preflight, and readiness for launch. To round out the investigation, supplemental information was obtained by direct interviews with the technical and maintenance staff of the aircraft squadron. After the information was gathered and arranged in mission/aircraft categories, it was reviewed again by cognizant technical personnel for clarity and accuracy before being used as the basis for actual program assignments.

To round out the scope of the report, typical mission assignments, profiles and performance envelopes for each of the aircraft studied in this investigation are contained in Appendix A.

AVIATOR PROTECTIVE EQUIPMENT AND PROBLEM AREAS

In order to facilitate clarity and comprehension of the problems identified for each of the various equipment components worn by the aviator, the information will be presented on an item by item basis from the top to the bottom, i.e., Helmet to Boots.

FLIGHT HELMET (APH-6)

Function

This item contains a number of components and sub-systems integral to the helmet proper. It is provided to the aviator to perform five basic functions:

1. Provide protection to the head against impact forces, buffeting, and vibration which can be encountered throughout the mission profile from launch to landing and recovery. It is not intended to provide ballistic armor-type protection.
2. Provide protection to the facial area, especially the eyes, by way of the Visor System. This protection is intended to protect the eyes and face against windblast, laceration, and penetration arising from fragmentation such as canopy fracture from ballistic strikes or ejection. A secondary aspect of the Visor System is protection of the eyes against glare.
3. Provide protection against hearing loss due to high ambient noise levels typical of jet engine operations which are often in excess of 90 db. This protection is effected through adjustable earcups mounted on the interior of the Helmet Shell, which can be positioned in both the vertical and horizontal plane.
4. Provide a stable and convenient base for the connection and integration of the Oxygen Mask and communication sensors to the aviator. Currently the helmet is being considered as a platform for items such as VTAS, Binocular Systems, and Visor Displayed Readouts and Emergency Warnings. The Oxygen Mask/Helmet Assembly affords additional protection to the face in the nose and mouth area during emergencies such as ballistic strikes and/or ejection through the canopy.

5. In survival situations, the entire Helmet Assembly provides protection against cold exposure and wind chill and can be used as a bucket to remove water from a life raft.

Specific Problems (APH-6 Helmet)

1. Helmet Sizing, Fit, and Comfort. The sizing, fit, and comfort was the most frequent source of complaint from the aviators in each of the different types of aircraft squadrons. Helmet Shell sizes are molded in three standard dimensions: small, medium, and large. Within each size, additional adjustment for fit can be effected by the placing of leather-faced foam rubber pads at various locations within the Shell interior. This process is referred to as "customizing the helmet fit".

Supplemental fitting is provided by adjusting the Nape Strap and the Chin Strap to the desired degree of tightness. In required cases, the Ear Cups, which also contain the earphones, can be adjusted to effect the best fit relative to comfort of the ears and maximum noise attenuation.

The net effect of the Helmet design configuration was that, in many cases, a satisfactory fit could not be achieved and/or maintained for sustained periods of time. This resulted in the following:

a. Helmet movement about the head and over the eyes during Air Combat Maneuvers (ACM) or sharp turns in flight involving positive "G" forces in excess of 2 "G". This is attributable to the poor profile of the Helmet and its misplaced center of gravity (CG).

b. General discomfort and specific pressure points around the ears and temples due to the weight of the Helmet Assembly (approximately 4.5 lbs) and uneven wear rates of the Helmet Liner Pads, especially the ear cups. This also induced head and neck fatigue. The Nape Strap with its limited adjustment range and the Chin Strap often contributed to helmet instability, general discomfort and pressure/chafing points on the nape of the neck and under the chin.

c. Excessive heat buildup in the head area. This characteristic was especially prominent in warm weather operations (air temperature 75°F and higher) or inside the cockpit with the canopy closed while awaiting takeoff or catapult launch. The aviators asserted that they sustained unnecessary heat accumulation and copious perspiration under such circumstances, which in turn contributes to premature fatigue and body fluid dehydration.

2. Visor Assembly. The integrated Dual Visors (1 Clear, 1 Tinted) presented a number of problems to the aviators during flight operations.

For the Clear Visor, the problems were:

a. The Clear Visor distorts the visual field and creates double vision and, in some cases, split vision when the aviator is viewing the various instruments and indicators in his cockpit during daylight. This problem is considered to be especially significant during carrier (CVA) take off and landings where an instrument scan for assessment of flight dynamics is necessary,

and the Helmet Visor must be worn in the down position for compliance with NATOPS safety standards.

b. The lower edge of the Visor produced a horizontal break in the aviator's field of vision when his eyes subtended a certain visual angle, e.g., looking ahead but downward at his lower instrument panel. In addition the Clear Visor travel is considered too limited in that it does not come as low as the Tinted Visor over the nose bridge of the Oxygen Mask.

c. The curved surface of the Visor is considered to be highly vulnerable to chipping, scratches, etc. with the attendant degradation of vision when it is worn in such condition.

For the Tinted Visor the problems were:

a. The degree of tint is considered by some pilots to be too dark for viewing their aircraft instruments in flight. This is especially true under marginal light levels. The pilots resolve the problem by lifting up the Tinted Visor and replacing it after the instrument review is completed. The aviators regard this as a nuisance.

b. The curved surface of the Tinted Visor is considered to be highly vulnerable to chipping, scratches, etc. with the related degradation of vision when worn in such condition. In balance, this would be true of any curved plastic surface unless a better transparent material can be developed for this use.

It is essential to stress that the problems identified in this investigation, from aviator remarks, have an opposite side which was conspicuous by its absence in the extended discussions with the aviators conducted in support of this work. This opposite side is the responsibility of the aviator to first obtain a proper fit at the outset, and exercise proper handling and maintenance of his own Flight Equipment on a continuing systematic basis. It became evident from the remarks of both the aviators and the parachute riggers that this responsibility was not being properly exercised by many aviators.

In essence, neglect of proper handling and maintenance exaggerates the basic inherent design deficiencies of the Helmet degrades assembly function, reduces aviator comfort and task performance, and results in premature or excessive fatigue levels throughout the mission profile.

From the evidence observed and the information gathered from the aviators, the parachute riggers, and various technical personnel associated with aviation safety equipment, it is clearly evident that a new lighter helmet design is a valid necessity for the Fighter/Attack community.

Recommendations

To this end, four fundamental recommendations for future design concepts can be offered.

1. Continue the pursuit and testing of new and emerging lightweight

materials for candidates as Helmet Shell prototypes. Many new materials have high strength-to-weight ratios such that they are lighter in weight and stronger than the current APH-6 fiberglass shell.

2. Continue the approach of building prototype Helmets and other candidates for future fleet use with formfit liners rather than pad set liners. This appears to be the most positive and enduring way to ensure helmet comfort, fit, and stability for sustained periods of time.

3. The heat problem continues to remain a persistent challenge to all designers. The essence of the problem lies in the fact that the head (as a heat source) obeys the second law of thermodynamics within the confines of a non-porous helmet. In view of these facts, it is highly recommended that the technology of Liquid Loop Head Cooling (which now exists in certain industrial applications) be integrated into the design and development of all helmet system candidates. All evidence and empirical test data obtained from NASA strongly point to the feasibility of this approach to resolve the problems of aviator heat buildup.

4. The bone or skin contact technique of voice transmission/reception system should be considered for integration into the design and development of prototype Helmet Systems. Its low weight, bulk, and simplicity make it a feasible candidate for the Helmet Communication System function.

These are minimum recommendations offered with the realization that the design and development of a Helmet is a difficult and complex effort which can only be conducted on an incremental trial and test basis. Moreover, the emerging configuration will inevitably be compromise/synthesis of many conflicting factors.

OXYGEN MASK (A-13A)

Function

This item is composed of several components and subsystems integral to its functioning. It is provided to the aviator to perform three basic functions:

1. Provide a continuous source of breathing oxygen to the aviator when worn under the required circumstances and conditions. This includes normal flight, high altitude ejection and descent, as well as emergency egress under water.

2. Provide a secure mounting base for the Microphone Assembly and serve as an ambient noise attenuator for the Lip Microphone.

3. Provide protection to the facial area it covers (in conjunction with the APH-6 or other type flight Helmet) during such emergencies as fire and ejection through the canopy. This protective function is augmented by the APH-6 Helmet to which the mask is attached. The mask attachment also serves to provide lower lateral helmet stability on the aviator's head.

Specific Problems (A-13A Mask)

1. Mask Fit, Function, and Comfort. Improper fitting was the most prevalent source of complaint and dissatisfaction from all of the aviators interviewed in this investigation.

The Mask comes in only three standard sizes: small, medium and large. The Mask Shell is made from flexible silicone rubber which can conform, to a limited extent, to irregular facial contours thus facilitating, to a limited degree, a close snug fit on the aviator's nose/mouth facial area when it is properly worn. Due to the three standard sizes and the many non-standard facial sizes and contours of the aviator population, a comfortable secure fit was not often attained and maintained. This resulted in the following:

a. Oxygen leaks around the upper rim of the Mask in the cheek area below the eyes, with the attendant problem of air-flow induced eye irritation. In some circumstances this was compounded by the aviator's own perspiration being blown up into his eyes and/or the interior surface of his Visor with corresponding degradation of vision. The bulk of the mask itself tended to reduce the field of vision when the wearer looked down at a steep angle onto his lower instrument panel.

b. Adjustment of the Mask assembly for a tighter fit and reduced leaks can often reduce the above problem. Under tight adjustment, the Mask profile exerts uncomfortable pressure on the face area covered by the mask, including the bridge of the nose, and some cases jams the Lip Microphone into the face, to the point where the pilots call it "eating the microphone".

c. In a certain few cases, the perspiration flow under a tight mask condition causes the sweat to drip into the lip microphone, shorting it out, and disrupting the communications in flight. In other cases the sweat pools in the exhalation valve port causing a "blubbering" effect during the exhale cycle.

Over a period of time, the sweat which has evaporated leaves a salt, crystal-like residue on the Exhalation Valve Disc. This can cause oxygen leakage through the valve with attendant waste of oxygen resources. If the Inhalation Valve does not seat properly due to foreign matter, the Exhalation Valve will not open due to the compensating feature of the Exhalation Valve, and the pilot cannot breathe. To correct this problem inflight, the pilot must remove the Mask and attempt to clean it as best he can. This fact again stresses the requirement for proper care and maintenance to prevent foreign matter buildup to such degrading proportions.

d. When the Oxygen Mask is worn in the tight adjustment condition and the aviator is moving his head under "G loading" during Air Combat Maneuvers (ACM), a torsional strain or deformation is frequently induced. This strain deformation can bind the Exhalation Valve Assembly and break compensation with the effect that the aviator cannot breathe until the condition is corrected, i.e., the strain is relieved.

e. In addition to this problem, the aviator often sustains a loss of Mask security under a normal 1 "G" load when moving his head from side to side or

looking down. This is because the Mask/Nose assembly bottoms out on the front and side surfaces of the bulky SV-2 Survival Vest. The semi-rigid hose also contributes to this problem because it pulls short on the Oxygen Mask due to insufficient length and flexibility. In concluding this point, it is noteworthy that the majority of the aviators favored return to the earlier "soft" flexi-hose in their oxygen system over the current semi-rigid "hard" hose which replaced it.

f. Under "G loads" in excess of 3 "G", the entire Mask (and Helmet) move on the aviator's face. As the "G load" increases, the Mask pulls down and away from the face in relative proportion (all other things being equal) to the "G loading". This requires the aviator to reposition the Mask (and Helmet) both during and after the "G loading". With the A-13A Mask pulled away from the pilot's face, breathing integrity as well as communication intelligibility (via the Lip Mike) are adversely affected in that the pilot loses the ability to talk clearly to the co-pilot or other pilots. In a combat environment this is very hazardous.

The problems of the Oxygen Mask pulling away from the face under "G loading" is a resultant of several factors which must be considered in combination with the basic heavy duty design of the Mask which is bulky and has a high profile on the face. These additional factors are:

(1) The length, weight, and bulk of the semi-rigid but flexible hose that feeds into the front of the Oxygen Mask to supply the oxygen from the aircraft to the aviator's Mask.

(2) The weight and bulk of the communicator (microphone) cable which is integral to the flexible hose. This cable has a phone jack for connection to the aircraft Interior Communication System (ICS).

(3) The in-line Oxygen Regulator "Mini Reg" which is fabric encased and attached by velcro to the front of the SV-2 Survival Vest. This Vest is bulky and restrictive in itself due to the items carried in the pockets on the front of the vest area, e.g., PRC Radio, Signal Flares, etc.

These three factors in conjunction with the protruding profile of the Oxygen Mask have weight and bulk which act as a leverage arm to pull the Oxygen Mask away from the face under increasing "G loads".

From the evidence observed and information gathered from the aviators, the parachute riggers and various technical personnel associated with aviation safety equipment, there is a valid need for a new design Oxygen Mask for the Fighter/Attack community.

Recommendations

Three basic recommendations for future new design concepts can be offered:

1. Incorporate a contact microphone into future prototype Oxygen Mask Systems. This will increase communication reliability and reduce weight. It will also enable the goal of minimum profile and bulk to be approached more closely.

2. Structure the future prototype design with the oxygen feed hose entering the Mask at a right angle, as opposed to bottom entry. This would eliminate the hose bottoming out on the Survival Vest/LPA assembly. The ideal solution would appear to be to provide the hose connection through the Helmet Shell as an integrated assembly.

3. Design a more reliable and durable Inhalation/Exhalation Valve Assembly that would better resist binding and the adverse effect of dirt and foreign matter upon its surfaces.

FLIGHT COVERALL

Function

This item is provided to the aviator to serve the following basic functions:

1. Provide a general utility garment for aviation and non-aviation duties, i.e., ground duties, ready-room standby, etc. With the exception of the Anti-Exposure Suit, it is the foundation garment over which the aviator wears all other items of flight gear.

2. Provide a fire-resistant envelope which, when properly worn by the aviator, will afford protection to his body and extremities against the direct effects of fire and flame. It will not provide protection against secondary effects of fire such as superheated air or thermal radiation.

Specific Problems (Flight Coverall)

1. Fit and Appearance. The unacceptability of fit and appearance was the most prevalent complaint heard from the aviators. The complaints ranged between a fit that was either too tight in width and length or too baggy overall. This, of course, reflected the wide range of body dimension of the population of aviators who wear the suit.

Related to this complaint of fit and appearance was the problem of launderability and durability. Many pilots complained that the zipper malfunctioned by jamming or stripping and that after repeated laundering the "life" went out of the fabric. Since there is a functional life expectancy of any item, and any item requires sustained proper care if it is to deliver its intended service to the user, the aspect of care and maintenance needs to be considered. Relative to all other items of flight gear, the Flight Suit is the most basic and receives the greatest wear for the longest period of time in both flying and non-flying activity. In all probability its service life is reduced accordingly.

2. Heat Retention. Many aviators reported that they experienced undesirable heat and sweat buildup when they wore the Flight Suit in warm and/or humid weather. They complained that the fabric of the suit did not "breathe" such that body heat dissipation was not sufficient to maintain comfort. To compensate for this problem, the aviators frequently wore the suit with sleeves rolled up and the front zipper opened. This is satisfactory for non-flying duties but hazardous for flight activities because of increased body exposure to fire hazard. The root of the problem appears to be in the inherent nature of the fire-proof Nomex fabric from which the suit is constructed. It is synthetic, non-porous, and woven to reduce the adverse effects of fire and heat on human flesh.

Recommendations

In view of these problems the following recommendations are offered to improve the acceptability of the Flight Coverall:

1. Redesign the garment to better accommodate the wide range of body dimension of the aviator population who wear the coverall.

2. Consider the integration of a Thermal Cooling System to be worn in conjunction with the coverall to reduce body heat buildup and, reduce the adverse thermal effects of the coverall on the aviator.

TORSO HARNESS (MA-2)

Function

This item is worn over the aviator's upper torso area. It is provided to the aviator to serve the following basic functions:

1. To provide an attachment/restraint to the Ejection Seat of the aircraft so that the effects of buffeting turbulence and severe flight maneuvers (G-loads) are minimized on the pilot.

2. To maintain a secure attachment/restraint to the Ejection Seat during the ejection sequence up to man/seat separation. After man/seat separation, the Torso Harness maintains secure attachment to the Rigid Seat Survival Kit and to the parachute system during descent to the ground.

3. To serve as a foundation garment for the attachment of the LPA Life Preserver to the torso of the pilot when the SV-2 Survival Vest is not used for the purpose of supporting the LPA Life Preserver.

4. To support a "D" ring for rescue lift capabilities to the downed aviator.

Specific Problems (MA-2 Torso Harness)

1. Fit and Sizing Adjustment. The problem of fit and size adjustment was the only significant problem reported on this item. The occurrence was predominant for large size men, chest size 44 and over, who wore the Torso Harness over an Anti-Exposure Suit. Even the extra large size Torso Harness could not be satisfactorily fitted over a large man wearing an Anti-Exposure Suit. The Torso Harness, when adjusted to maximum dimensions with an extender strap, could be worn over the man wearing an exposure suit but the penalty, in terms of compression/constriction and chafing during flight were, from the wearer's point of view, "miserable".

In addition to this condition, forces such as catapult launches, in-flight "G-loads", and carrier landings increased the problem significantly. This was especially prominent for the Koch Fittings which dig into the flesh of the shoulder/collarbone area under "G loads" during launch and recovery operations.

The root of the problem appears to lie in the fact that the extra large MA-2 Torso Harnesses were not designed and produced to wear over the girth of a large man, chest size 44 and larger.

Recommendations

1. In view of the significant functions that the MA-2 Torso Harness performs, it is recommended that efforts be implemented as soon as practical to produce and supply extra large torso harnesses for aviators with large chest dimensions.

2. For all torso harnesses, it is recommended that a piece of padding material be attached to the harness under the Koch Fittings to reduce the pain and discomfort of the fittings on the shoulder/collarbone areas under "G" loading.

SURVIVAL VEST (SV-2)

Function

This item is worn on the aviator's upper torso and chest area. It is provided to the aviator to serve the following basic functions:

1. Provide a stable secure mounting for the chest Regulator and a stowage area for any emergency equipment that the aviator may require for survival and rescue after he ejects or ditches from the aircraft.

2. Provide a secure set of attachment points for the connection and integration of the LPA Life Preserver so that balanced buoyancy is maintained if the aviator is immersed in water after an emergency ejection.

The SV-2 is often worn in conjunction with the MA-2 Torso Harness and the LPA Life Preserver which in turn are all worn over the Flight Suit. This necessary combination does produce a number of complaints centering on bulk, restrictiveness, and body-heat build up.

Specific Problems (SV-2 Survival Vest)

1. Equipment Encumbrance and Bulk. This problem was the most frequently mentioned by all the aviators in all the squadrons. The first focal point was the bulk protruding on the front chest portion of the SV-2 Vest. This protrusion is caused by the PRC series Radio, Flares, Knife, etc. in the chest pockets/pouches of the vest. Thus it is not the vest itself which is the cause of the problem but rather the equipment carried within the vest structure. With respect to the bulk protruding on the front chest, there are two problems that emerge from this condition.

a. The A-13A Oxygen Mask and related hose assembly bottom out on the front of the Survival Vest when the aviator lowers his head to look down. This is due to the relatively high bulk profiles of both the Mask and Vest contacting each other. The result of this disrupts the facial integrity of the Oxygen Mask and requires the aviator to reposition the mask to restore integrity.

b. In certain instances, the control stick of the aircraft, such as in the A-4, bumps into the front bulk of the vest when it is worn by a large man. This limits its full axis of rear movement by about 3 inches. The limitation of stick movement in the rear direction of travel is not excessive and most aviators did not regard this as a critical problem but it was distinctly viewed as discomforting and unnecessary. Pilot opinion and attitude toward this restriction varies in terms of severity. Regardless of this, a reduction in the restriction of control stick movement in the front to rear plane would be a positive asset to the larger size pilots who fly this aircraft.

2. Fit and Sizing; Body Heat Buildup. The SV-2 Vest is an inherently cumbersome item because of the many packets of equipment it must hold on the front and sides of the chest and upper torso area. In addition, the Vest is worn in conjunction with the LPA Life Preserver and the MA-2 Torso Harness, both of which have an inherent degree of weight and bulk.

The final variable which contributes to the fit and heat problems is that the entire assembly is worn over a Flight Suit and/or Anti-Exposure Suit, e.g., CWU 33/P. The net results of these combinations of conditions are variations in the aviator's torso and limb girth which in turn significantly affect the fit and sizing of the Vest and its adjustability. It is important to note that these fit/sizing problems were most prominent with the large size aviators. An aviator who normally required a large adjusted SV-2 Vest (without an Anti-Exposure Suit) had the greatest difficulty in effecting satisfactory adjustment of the vest when he wore an Anti-Exposure Suit. In essence he was at the adjustment limits of the vest unless extra spacer panels were sewn in by the parachute riggers at the man's own request.

A separate, but related, problem to Vest sizing and fit was reported in the area of Vest stability. During catapult launch from an aircraft carrier and during ACM maneuvers under varying "G loads", the entire Vest assembly moves around the torso. This necessitates frequent readjustment and/or repositioning of the bulky Vest on the torso in flight in order to minimize interference with side arm reach and torso movement. The aviators regard this as a relatively minor but persistent nuisance.

Due to the nylon fabric used in the construction of the Vest and the fact that it is worn over the nylon Torso Harness (MA-2), a certain degree of sliding is probably inevitable. The surfaces of these two synthetic materials have relatively low friction levels, thus they can slide easily over each other under "G loads".

The SV-2 Vest and nylon Torso Harness are both constructed of heavy woven materials which retain body heat. When worn together (along with an LPA Life Preserver and Nomex Flight Suit), body heat buildup is virtually inevitable because of the layering effect which blocks body heat dissipation by radiation and convection.

Recommendations

Navy and Air Force study results, including downed Navy aviator debriefs, repeatedly documented only minimal usage of SV-2 Vest Equipment while the aviator was downed and/or in a survival situation. This fact, when coupled with

the concept of a "24 hour SAR Capability", greatly reduces the necessity for extensive man mounted survival equipment. In essence, Signal Equipment and First Aid items were about the only things that had any usage. The rest of the equipment was not used and, in many cases, was simply discarded.

The net conclusion of this is that operational experience has probably made the SV-2 Vest obsolete as a separate carrier for survival equipment. The recommendations here are twofold:

1. Conduct a complete and detailed review of the actual usage rate of Survival Equipment over the past 5 or 10 years.
2. Integrate the equipment, which this study indicates is really required, into the current MA-2 Torso Harness to form a modular system configuration for wearer flexibility. The savings in weight, bulk, cost and heat buildup which would result from this investigation are obvious. This investigation has confirmed the fact that several jet training squadrons (VT) have been doing this for several years and, more recently, a few fleet squadrons in the southern United States are in the process of doing the same. To date, no adverse results have been reported.

In balance it should be stressed that an approach such as this which affects fleet operating safety must be carefully studied and tested. The recommendation at this point is that a serious and concerted effort be started to review this approach with the end objective of eliminating the SV-2 Vest.

LIFE PRESERVER (LPA-2)

Function

This item is worn on the aviator's upper torso and, when inflated, consists of body lobes and a neck collar. It is provided to the aviator to serve the following basic function:

1. Provide the aviator with a stable and reliable flotation capability while in water following emergency egress or ejection from a disabled aircraft.

In essence, the LPA-2 is an emergency function item. Accordingly, during normal flight it is worn passively on the man and has no operational function or protective capabilities.

Specific Problems (LPA-2 Life Preserver)

1. Chafing and Irritation of the Neck. The most frequent complaint from the aviators was the chafing on the back of the neck from the collar of the uninflated LPA. The collar fabric covering is a rugged, nylon fabric which, over a long period of time, will chafe the skin.

2. Sizing and Adjustment Problems. When the LPA is worn in conjunction with an Anti-Exposure Suit, many pilots report significant difficulty in securing the LPA attachment straps around their body due to insufficient length

for expanding the adjustment diameter. It is evident that the design of the securing and adjustment system did not allow for the extra length required when worn over the bulk of an Anti-Exposure Suit. This problem is particularly prominent for large men (chest size 44" and larger) attempting to wear the LPA over their Anti-Exposure Suit. For these large men, the only way to resolve the problem is to have the parachute riggers sew extra lengths of straps onto the waistband straps so that adequate and comfortable adjustments can be made. The implication of this is that these ad hoc corrections may vary from squadron to squadron in terms of materials, quality, and workmanship. This in turn could compromise the effectiveness of the LPA especially through continued usage and/or windblast during ejection. Since the LPA is an emergency item, the latitude for malfunction is small while the hazard potential is large.

Recommendations

1. It appears as if the most simple and economical solution to the chafing problem would be a small length of soft fireproof fabric easily attached/detached to the inner curve of the collar of the LPA. This would blunt the chafing effect and could be easily laundered and/or replaced as needed.
2. In view of the problems of size adjustment, a uniform standard method should be developed so that any corrective action effected will maintain the integral securing quality of the basic LPA assembly.

ANTI-EXPOSURE SUIT (CWU/33P)

Function

This item is provided to the aviator for wear when he is conducting flight operations in cold weather or over cold water. The Suit is specified to wear when the thermal envelope (air/water) temperature is less than 120°F (combined). The Suit is specifically designed to provide protection against the effects of immersion hypothermia which the aviator may encounter in the water after an emergency aircraft egress. The Anti-Exposure Suit is configured with ventilation panels which conduct air through the Suit when connected to an existing suitable air source via a flexible hose which has quick coupling connect/disconnect fitting.

Specific Problems (Anti-Exposure Suit CWU/33P)

1. Severe Restriction of Mobility. For these aviators having an appropriate size to wear, the problem of mobility restriction was reported with dismal frequency. The most severe restriction on mobility of the wearer was centered primarily on arm reach and flexion.

These two functions relate directly to the aviator operating the controls and equipment within the envelope of the aircraft cockpit.

Restrictions on reach and mobility produce premature and unnecessary fatigue and degrade aviator performance. Reach and mobility restrictions are further compounded under "G-loading" such as Air Combat Maneuvers (ACM). Many fighter

pilots vigorously asserted that they could not effectively perform ACM while wearing the Anti-Exposure Suit and Anti-"G" Suit combination. Thus, they often do not wear the Anti-Exposure Suit and expose themselves to unnecessary hazards in cold weather.

Recommendations

In view of the above problem and the necessary protective requirements to be maintained, it is recommended that future Anti-Exposure Suits be designed with accordion pleat type joints or other stress relief features at the elbows, shoulders and knees so that maximum reach and flexibility can be assured. This approach would still maintain the protective integrity of the garment.

ANTI-G SUIT (MK-2A)

Function

This item is worn around the aviator's legs and abdomen. It is provided to the aviator to serve the following basic function:

Provide improved tolerance/protection against G forces sustained during various phases of flight, e.g., air combat maneuvers (ACM). The protective capability is designed to be maximally effective when G forces are encountered.

When the Anti-G Suit is worn over the standard flight coveralls and properly secured in place with the adjustments provided, the Suit performs its intended functions in an effective manner. The pilots who used the Suit on a regular basis were satisfied with the donning/doffing, adjustments and in-flight comfort that the Suit afforded them.

Specific Problems (Anti-G Suit MK-2A)

1. Integrated Fit and Effectiveness. The Anti-G Suit is one part of a total protective system to be worn by the aviator. When it is worn in conjunction with the Anti-Exposure Suit, its effectiveness is reduced due to the following factors:

a. Insufficient Size. In this case the maximum adjustment diameter of the Anti-G Suit is often insufficient to permit it to be worn around and over the CWU/33P Anti-Exposure Suit. This problem is particularly evident with aviators who normally wear a Large size. In effect, the combination of a large man wearing a large size Anti-Exposure Suit creates a combined girth diameter that exceeds even the maximum adjustment range of the largest size Anti-G Suit presently made. This is fundamentally a sizing problem for this spectrum of the aviator population. It should be noted that the close-fit design of the Anti-Exposure Suit (CWU/33P) makes it practically impossible to wear the Anti-G Suit under it. The Anti-G Suit must be worn over the Anti-Exposure Suit for all sizes of the aviator population.

b. Material Attenuation. The neoprene foam of the Anti-Exposure Suit compresses under the constrictive effects of the inflating Anti-G Suit. In so doing, the protective function of the Anti-G Suit is significantly attenuated since the pooling of blood in the legs (positive G loading) is not retarded to

the degree it would be if the Anti-G Suit were acting directly on the aviator's legs. At this time, there is no quantitative physiological evidence comparing the effects of the Anti-G Suit being worn with and without the CWU/33P Anti-Exposure Suit, although aviators who had flown with both configurations consistently reported that the protective function of the Anti-G Suit was degraded when worn in conjunction with an Anti-Exposure Suit.

Recommendations

In view of the lack of quantitative physiological evidence, the subjective nature of the aviators' judgment and the potential serious consequences of this condition, it is recommended that a systematic investigation be conducted to collect empirical data to determine the nature and extent of this attenuation problem so that corrective action can be effected when feasible.

FLIGHT GLOVES

Function

This item is worn over the aviator's palms and fingers during flight to provide the following basic functions:

1. Provide a general utility function to protect the hands from minor nicks, abrasions and contact burns from heated surfaces which may be encountered during pre-flight and in-flight operations. During cold weather operations, the gloves provide a marginal capability against the effects of cold and thermal chilling by direct contact.
2. Provide a fireproof envelope to protect the aviator's hands against the direct effects of fire and flame which may be encountered during an emergency.

The gloves are constructed in a variety of sizes and fabricated from a woven Nomex Fibre with a reinforcement of leather, integrated to the palm and fingers, for extra protection against abrasive wear due to repeated contact with controls, switches, levers, etc.

Specific Problems (Flight Gloves)

1. Lack of Flexibility/Pliability. The complaints reported on this item were relatively minor and infrequent but they consistently tended to point to problems in the area of fit and flexibility. These problems were accentuated when the Glove(s) had been wet from sweat and/or laundering.

When the Gloves were dried out they tended to shrink and become stiff and, in effect, the entire Glove lost its pliability. When this happened, the pilots reported a loss of touch sensitivity although none of the pilots reported that this severely affected their ability to fly and operate the aircraft and its equipment systems.

Recommendations

For future Glove designs using newer, emerging, fabric technologies, it is

recommended that fabrics be employed that have better launderability properties so that their flexibility/pliability be maintained without sacrificing their fire-resistant capability.

FLIGHT BOOTS

Function

The standard aviator's leather Flight Boot is worn over the aviator's toe, instep, and ankle (to near mid-calf length) to provide the following basic functions:

1. Provide a general work/utility shoe for ground and flight duties. These boots have a steel shelled toe which protects the toes from injuries sustained from falling objects. These have neoprene soles/heels for traction/stability.
2. Provide limited thermal protection for the foot and lower leg against both winter cold and the direct effects of fire and flame. The boots are not fireproof or insulated, hence their thermal protective capability is only marginal.

Specific Problems (Flight Boots)

The pilots interviewed about this item consistently requested an improvement in the Anti-Skid Capability of the Boot. In both ship-board and land-based areas, the Boots offer only limited anti-skid protection, especially on surfaces coated with oil or grease. Several pilots reported losing their balance when encumbered with a normal complement of flight gear (about 40 extra lbs. of weight) as they walked across a grease or oil spotted flight line. In view of the inherent lubricating or friction reducing qualities of oil and grease, it is recognized that this is a difficult problem to resolve and one which might be better handled by prevention (better housekeeping) than through redesign.

Recommendations

In view of these problems, it is suggested that a review of sole/heel traction configurations be conducted to determine if there are any cost effective solutions now available.

C O N C L U S I O N

A number of significant problems associated with the life support and protective equipment worn by the aviators of the Fighter/Attack community have been identified and defined for each of the various equipment systems. However, it is important to stress that the redevelopment of protective equipment systems should not necessarily be pursued on a unit-for-unit basis. The following objectives of ADO 45-67 (AircREW Protective Clothing and Devices Systems) clearly state that newly developed equipment should be:

- ° Multi-Functioned
- ° Modular/Integrated
- ° Low in Weight and Bulk

These factors should be the governing parameters and the driving force behind future protective systems development. In addition, this approach will ensure the incorporation of new technologies in such areas as:

- Thermal systems for body cooling and heating
- More efficient and reliable communication systems
- Improved materials and system fabrication techniques

The ever increasing sophistication, power, and range of new and emerging Fighter/Attack aircraft have increased the requirements on the aviators for sustained effective performance in their mission envelope to demanding proportions. If optimum effective integration of the man/aircraft system is to be attained, it must be accompanied by the comparable achievements in the man/protective system integration needed to correct problems such as those identified in this study effort.

APPENDIX A
AIRCRAFT/MISSION DESCRIPTIONS

F-4 SERIES AIRCRAFT

U. S. NAVY DESIGNATION: F-4, RF-4

INTRODUCTION

The Phantom II was developed by the McDonnell Douglas Aircraft Corporation with a manufacturer's designation, retained by the Navy, as the "Phantom". The aircraft was developed initially as a twin-engine, two seat, long-range, all-weather attack fighter, for service with the Navy from land based and sea based (CVA) platforms.

Currently, the U.S. Navy owns and operates several variations of the basic F-4 airframe; only these will be considered here. These variations are summarized as follows:

F-4B (Phantom II)

This is an all-weather fighter for the U.S. Navy and Marine Corps. It is powered by two G.E. J79-GE-8 turbo jet engines. Over 600 of these aircraft saw active service in the inventory (together with the earlier limited F-4A).

RF-4B (Phantom II)

This is a multi-sensor reconnaissance version of the F-4B for the U.S. Marine Corps to conduct high speed tactical area reconnaissance. It does not contain dual controls or armament.

F-4G (Phantom II)

This was developed for the U.S. Navy with data link communications equipment. It saw service in Vietnam from the USS Kitty Hawk. As a limited production aircraft, only 12 were built under F-4B production quotas.

F-4J (Phantom II)

This was developed for both the U.S. Navy and Marine Corps primarily as an interceptor but with full attack capability. This model was also used by the Navy's Blue Angels demonstration team.

F-4N (Phantom II)

The Navy is updating 178 F-4B's under this designation. The update will include increased systems capability and power.

The significant value of the Phantom II is underscored by a total production delivery of 4,260 units since 1 January 1973. The aircraft has set up

many official records since 1959. Many of these records are still standing to date.

SUMMARY OF TACTICAL MISSIONS

The versatility and durability of the F-4 series aircraft is evidenced by its various mission capabilities which are summarized as follows:

1. All weather attack fighter (F-4B)
2. Reconnaissance/Intelligence (RF-4B)
3. High speed Interceptor/Attack (F-4J and F-4N)

MISSION PROFILE SUMMARY (See Figure 1)

For purposes of security and simplicity the F-4 Mission Profile (Interceptor/Attack Mission) has been abbreviated to outline form. The listed speeds and altitude levels may and do vary according to mission assignments, threat levels, and environmental conditions.

The at-sea (CVA based) mission time for the F-4 is normally 1 1/2 to 2 hours. With in-flight refueling the mission time can be extended to 3 to 3 1/2 hours maximum.

CREW COMPOSITION AND FUNCTIONS

The F-4 series aircraft, regardless of mission, has a two man crew consisting of a Pilot with either a Radar Intercept Officer (RIO) in the back seat or a Naval Flight Officer (NFO) operating the special reconnaissance equipment. Whatever the case, the two men function as a closely coordinated team.

The pilot is the mission commander and has primary responsibility for the safe operation and control of the aircraft throughout the mission profile.

The RIO or NFO is responsible for the control and employment of the sophisticated electronic systems which include navigation, sensors, and fire control equipment. Since this is a high performance aircraft capable of functioning in excess of Mach 2, the major physical stress sustained by both men is the various "G" load vectors, especially during Air Combat Maneuvers (ACM).

For both men the physical tasks performed are in the nature of small precision movements aimed at effecting adjustments in the flight controls, navigator/sensor systems and/or fire control equipment, when engaging an enemy aircraft. All of these tasks demand a high degree of intellective judgment and coordination. This, plus the demands of a combat/intercept mission, does give rise to fatigue especially in the later return/recovery phase.

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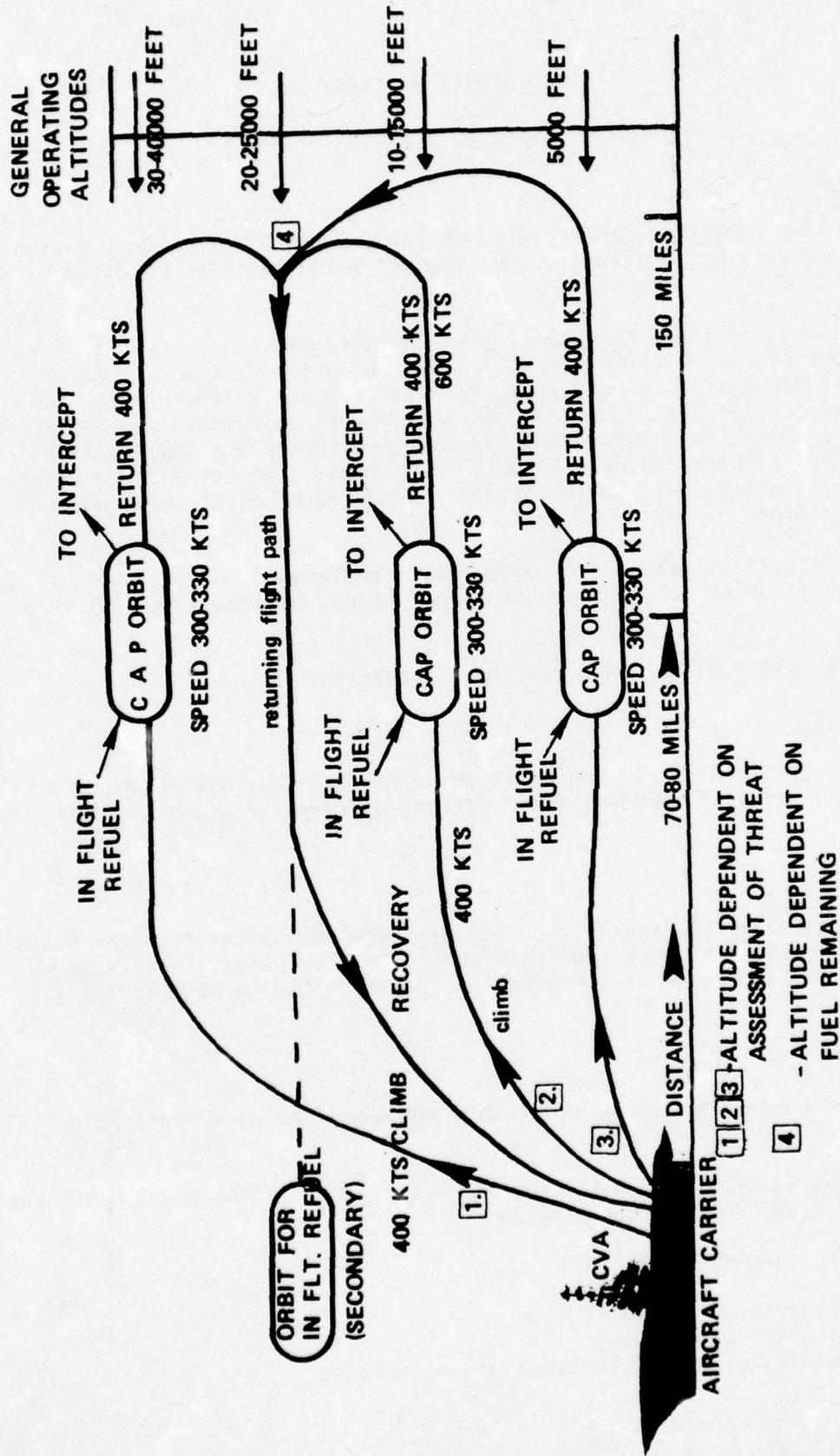


Figure 1. F-4 Mission Profile.
Fleet Defense - Combat Air Patrol.

F-14 SERIES AIRCRAFT

U. S. NAVY DESIGNATION: F-14A, F-14B, F-14C

INTRODUCTION

The F-14 aircraft is manufactured by the Grumman Aircraft Corporation. The manufacturer's designation is the "Tomcat" which has been retained by the Navy.

The F-14 is designed to fulfill three primary missions. The first is fighter/sweep escort which involves clearing contested airspace of enemy fighters and protecting the strike force, with support from early warning aircraft, surface ships and communications networks to coordinate penetration and escape. The second is a defense of carrier task forces via Combat Air Patrol (CAP) and Deck Launched Intercept (DLI) operations. The third is secondary attack of tactical targets on the ground, supported by electronic counter-measures and fighter escort.

This aircraft is intended as a follow-on replacement of the ageing F-4 series aircraft which it surpasses in speed, range, endurance and avionics systems.

Three versions of the F-14 have been projected:

F-14A (Tomcat)

This is the initial version built as a two-seat, carrier based, multi-role fighter. It is powered by two Pratt and Whitney turbofans of 21,000 lbs of thrust.

F-14B (Tomcat)

This version has basically the same airframe and avionics as the F-14A but it is powered by an improved Pratt and Whitney turbofan (twin) system. It is expected to be capable of acceleration from Mach 0.8 to Mach 1.8 in 1.27 minutes.

F-14C (Tomcat)

This is to have new avionics and weapons when funding authorizations are granted.

The first squadrons of F-14's became operational in the Navy on the West Coast aboard a CVA in the fall of 1974.

SUMMARY OF TACTICAL MISSIONS

1. Fighter/Sweep Escort
2. Strike force defense
3. Secondary attack of tactical ground targets

The F-14 aircraft has not been operational long enough to determine which of the above missions are the most demanding on the man and the life support equipment requirements. Its inherent high performance capabilities can subject the man to high "G" loads in different vectors as Air Combat Maneuvers (ACM) are conducted in pursuit of enemy aircraft. Indeed, if the full performance capabilities of the aircraft are to be realized, adequate "G" protection must be afforded at all times.

MISSION PROFILE SUMMARY (See Figure 2)

For purposes of security and simplicity the F-14 Mission Profile has been abbreviated to outline form. The listed speed and altitudes may and do vary according to mission assignments, threat levels, and environmental factors.

The at-sea mission time for the F-14 is normally 2 hours. With an in-flight refuel the mission time can be extended up to a maximum of 3 3/4 hours.

CREW COMPOSITION AND FUNCTIONS

The F-14 aircraft has a two man crew of a Pilot and a Radar Intercept Officer (RIO). The duties of each are necessarily integrated and each must contribute coordination and support to the overall performance of the other.

The pilot is the aircraft commander and is responsible for the safe operation and control of the aircraft throughout its entire mission.

The RIO coordinates his activities with the pilot for navigation, sensor operation, and monitoring, as well as fire control of the weapons system.

These basic activities are implemented by a number of small precision movements directed at effecting adjustments in the various system controls. All of these tasks require a high degree of intellective judgment and coordination. Although there are no major gross physical tasks required of the crewmen, the demands of the mission for speed, precision, and skill, especially under combat conditons, do give rise to fatigue especially under the demands of a sustained combat mission against enemy forces.

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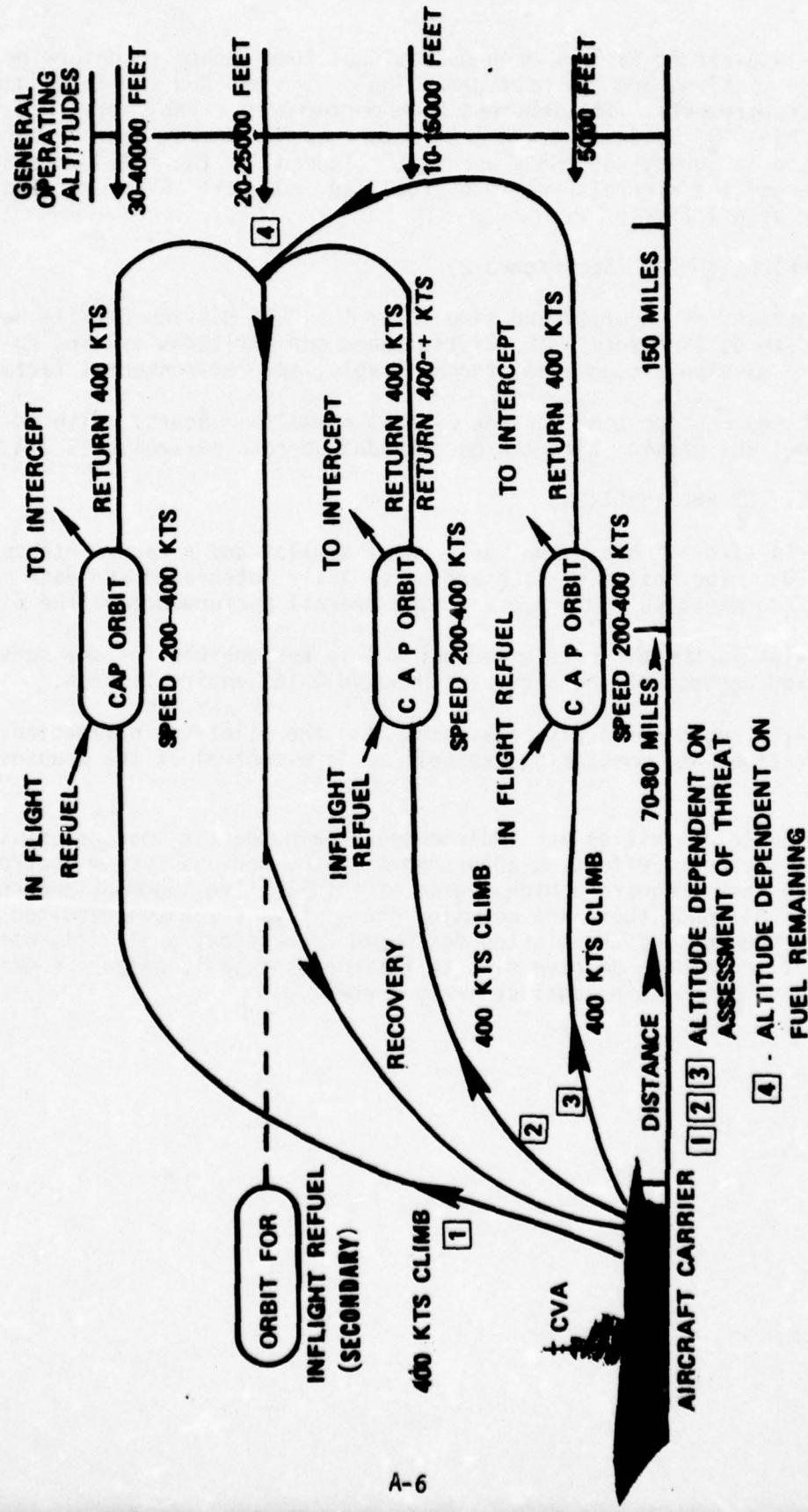


Figure 2. F-14 Mission Profile.
Fleet Defense - Combat Air Patrol.

A-4 SERIES AIRCRAFT

U.S. NAVY DESIGNATION: A-4 and TA-4

INTRODUCTION

The A-4 aircraft was designed originally to provide the U.S. Navy and Marine Corps with a simple low-cost lightweight attack and ground support aircraft. The McDonnell Douglas "Skyhawk" was designed from experience gained during the Korean war.

Since the initial requirement called for operation by the U.S. Navy, special design consideration was given to providing low-speed control and stability during take-off and landing, added strength for catapult launch and carrier arrested landings, and dimensions that would permit it to negotiate standard aircraft carrier lifts without the complexity and problems of folding wings. Production of the "Skyhawk" began in 1953 and continues to date with various modifications.

A number of these versatile well proven aircraft have been built for foreign governments, including the Royal New Zealand Air Force, the Argentine Navy and Air Force, and Israel.

Currently the U.S. Navy owns and operates several variations of the basic A-4 airframe; only these will be considered here. These variations are summarized as follows:

A-4A (Skyhawk)

This is the initial version with a 7,700 lb. thrust engine. It entered service with the U.S. Atlantic and Pacific Fleets in October 1956; a total of 166 were built. Improved engines of 8,500 lb. thrust were fitted progressively to all aircraft.

A-4B Skyhawk (Formerly A-4D)

This has increased payload and 27 percent greater range with 8,500 lb. thrust engine, Douglas Escapac 0/90 ejection seat, maximum ordnance load of 8,000 lbs. Forty-nine were built in production.

A-4F (Skyhawk)

Light attack bomber with 9,300 lb. thrust engine, new lift-spoilers on wings to shorten landing distance, 0/0 ejection seat, additional bullet and flak-resistant materials to protect pilot, and updated electronics. One hundred forty-six were built in production.

TA-4F (Skyhawk)

Tandem two-seat dual control trainer of the A-4F with Douglas Escapac ejection seats.

TA-4J (Skyhawk)

Tandem two-seat trainer, basically a simplified version of the TA-4F.

A-4L (Skyhawk)

A modified A-4C with improved engine, bombing computation system, and avionics.

A-4M (Skyhawk)

Similar to the A-4F but with an improved 11,200 lb. thrust engine, and braking parachute (standard), making possible combat operation from 4,000 ft. fields. Increased ammunition capacity for 20 mm cannon. Initial order of 50 for U.S. Marine Corps with additional orders placed.

SUMMARY OF TACTICAL MISSIONS

The versatility of the A-4 series aircraft is evidenced by its various mission capabilities which are summarized as follows:

1. Carrier based light attack aircraft	(A-4A)
2. Light tanker refueling aircraft	(A-4B)
3. Light attack bomber	(A-4F)
4. Trainer aircraft	(TA-4F)
5. High performance attack aircraft (including USMC Close Air Support)	(A-4M)

For all the various missions and models of this aircraft, the most demanding are those which originate from a CVA platform due to the stresses of launch and recovery.

MISSION PROFILE SUMMARY (See Figure 3)

For purposes of security and simplicity, the A-4 Mission Profile (attack mission) has been abbreviated to outline form. The listed speed and altitude may vary according to mission assignments, threat level, and environmental conditions.

The at-sea mission time for the A-4 is normally 2 1/2 to 3 hours maximum.

CREW COMPOSITION AND FUNCTIONS

Except for the tandem seat TA-4F/J series trainers, the aircraft is a single seat Pilot-only aircraft with the dual function of flying the aircraft and delivering the weapons/ordnance on the designated targets. These functions are implemented through a sequence of precise movements and intellective judgments requiring skill and coordination.

Although there are no gross physical tasks required of the Pilot of this aircraft, the cumulative effects of fatigue are reported to be most in evidence in the terminal portions of the mission profile after being in the cramped, tiny cockpit for 2 to 3 hours of flight time.

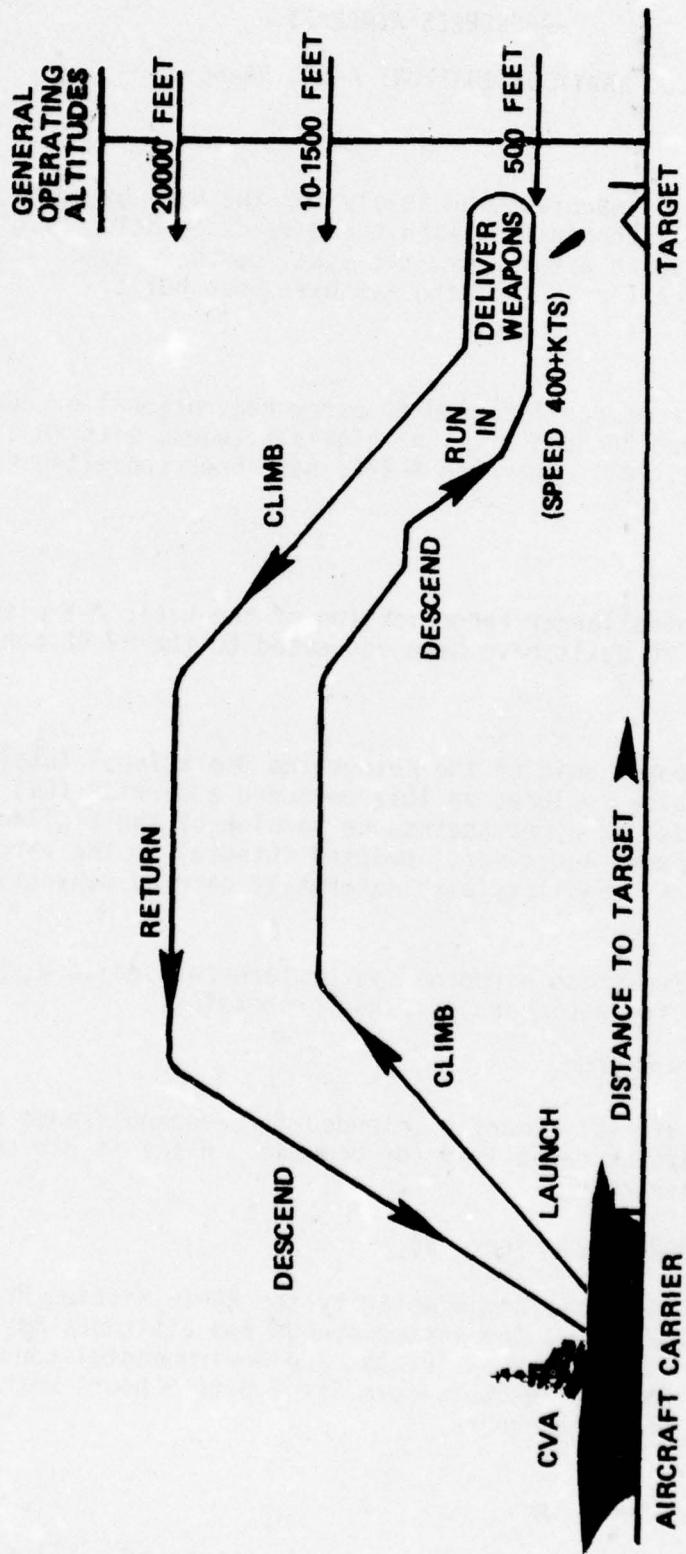


Figure 3. A-4 Mission Profile.
Attack Mission.

A-5 SERIES AIRCRAFT

U.S. NAVY DESIGNATION: A-5A, RA-5C

INTRODUCTION

The A-5 aircraft is manufactured solely for the Navy by contract with the North American Rockwell Corporation with the Navy designation "Vigilante". It was originally designed as a twin-jet, two-seat, carrier-based, all-weather combat aircraft. Three versions of the A-5 have been built:

A-5A (Vigilante)

This is an attack bomber intended to carry conventional or nuclear weapons over a range of several hundred miles at high altitudes, with an over target speed of about Mach 2. All remaining A-5A's have been converted to an RA-5C configuration.

A-5B (Vigilante)

This is an improved larger range version of the basic A-5 with extra fuel storage. All of the 20 built have been converted to the RA-5C configuration.

RA-5C (Vigilante)

This is the airborne unit of the Integrated Operational Intelligence System (IOIS) which also includes an IOIS on board a carrier (CV) or at a shore base. This model is a reconnaissance version of the Vigilante with tactical sensor equipment and cameras mounted integral to the aircraft. It also retains an attack capability with externally carried conventional or nuclear weapons.

Data obtained from these airborne systems are relayed to a surface based tactical data system for rapid analysis and processing.

SUMMARY OF TACTICAL MISSIONS

The RA-5C aircraft is primarily intended for reconnaissance operations but it does retain the attack capability for bombing. Hence it can serve the fleet as a dual function aircraft.

MISSION PROFILE SUMMARY (See Figure 4)

For purposes of security and simplicity the RA-5C Mission Profile has been abbreviated to outline form. The listed speeds and altitudes may vary according to mission assignments, threat levels, and environmental conditions. The at-sea mission time for the RA-5C is normally 2.5 to 3 hours with refueling providing a maximum time of 6 hours.

CREW COMPOSITION AND FUNCTION

The RA-5C aircraft has a two man crew consisting of a Pilot and a Naval Flight Officer (NFO) sensor station operator. Their duties are necessarily

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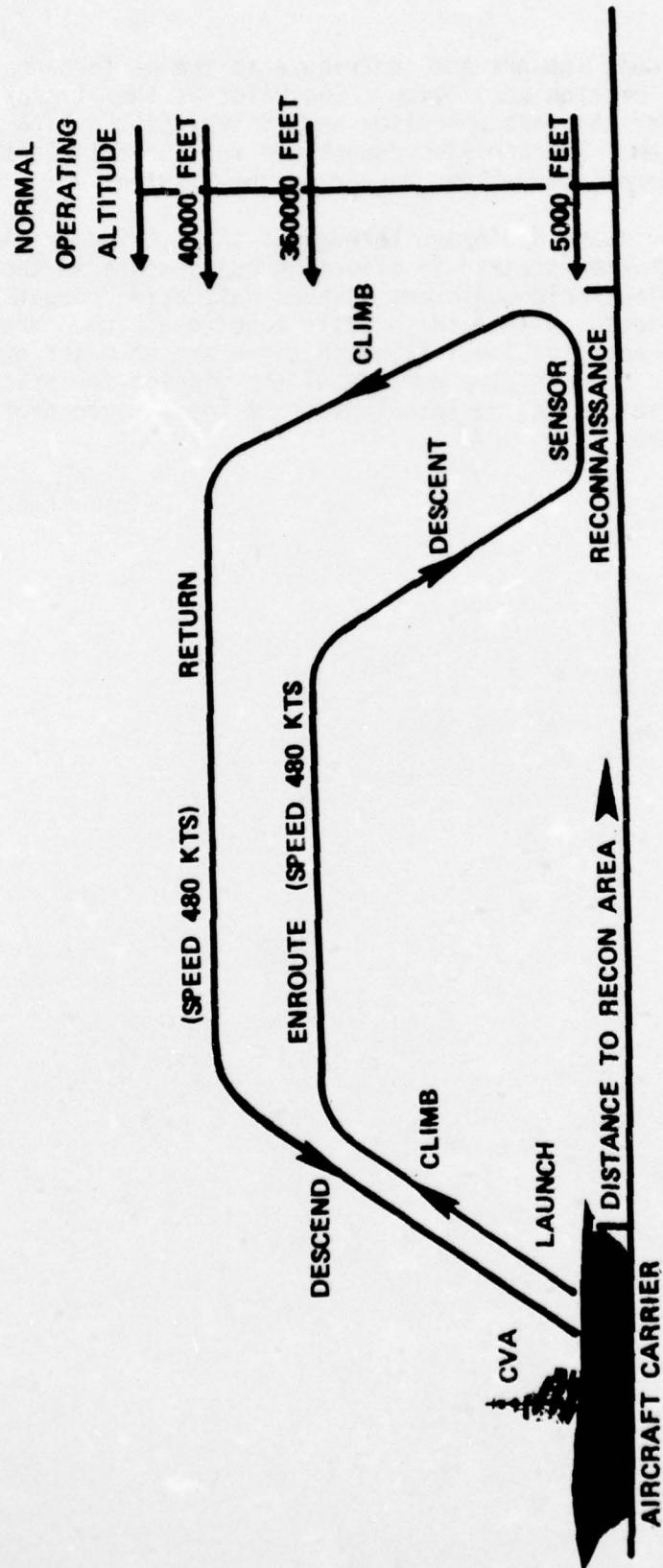


Figure 4. RA-5 Mission Profile.
Reconnaissance Mission Profile.

integrated and each must support and contribute to the performance of the other to ensure successful mission completion. The Pilot is the aircraft commander and is responsible for the safe operation and control of the aircraft throughout its entire mission. The NFO is responsible for the efficient control and operation of the reconnaissance sensors during the mission.

For both men the tasks performed throughout the mission are in the nature of small precision movements aimed at effecting adjustments in the flight controls and numerous electronic equipment such as navigation computers, radios, radar and sensor systems. All of these tasks require a high degree of intellectual judgment and coordination. Although there are no major gross physical tasks required of the crewmen, the demands of the mission for precision do give rise to cumulative fatigue in the later phases of the mission profile and the carrier recovery phase.

A-6 SERIES AIRCRAFT

U.S. NAVY DESIGNATION: A-6, EA-6, and KA-6

INTRODUCTION

The basic A-6A aircraft is manufactured by the Grumman Aircraft Corporation with a manufacturer's designation as the "Intruder" for the A-6 series and "Prowler" for the EA-6 series.

The basic A-6A aircraft was designed as a carrier-based, low altitude, high performance attack bomber with the capability to deliver conventional or nuclear weapons on designated targets. The aircraft has the capability to effect this mission day or night in any kind of weather.

Aircraft speed is subsonic but the A-6 has superior endurance and a heavier payload than any previous attack aircraft in the naval air inventory.

Currently, the U.S. Navy owns and operates seven variations of the basic A-6 airframe. These variations are summarized as follows:

A-6A (Intruder)

This is the initial version to enter the Naval Air Forces (1963). It is a carrier-based attack aircraft all of which are, or will be, modified to the A-6E.

EA-6A (Prowler)

This is a modified attack mission with the capability for tactical electronic missions, i.e., enemy radar jamming and electronic intelligence-gathering in a combat zone. The primary user is the U.S. Marine Corps.

EA-6B (Prowler)

This is an advanced version of the EA-6A modified to have two additional crewmen to operate the electronic system.

A-6B (Intruder)

This is a modified A-6A to provide an advanced avionics system and missile delivery capability.

A-6C (Intruder)

This is an advanced A-6A with expanded night attack capability through Forward Looking Infra Red (FLIR) sensors and Low Light Level Television (LLTV), and associated high resolution displays.

KA-6D (Intruder)

This is a modified A-6A airframe to provide inflight refueling and/or tactical control system for air-sea rescue operations while retaining capability as a day bomber.

A-6E (Intruder)

This is the newest modification of the A-6A airframe containing multi-mode radar and an IBM computer system. It entered service in 1972. It is considered the most sophisticated and versatile attack aircraft in the naval air operating inventory.

SUMMARY OF TACTICAL MISSIONS

The versatility of the A-6 series aircraft is evidenced by its various mission capabilities which are summarized as follows:

1. All Weather Day/Night Attack Mission (A-6A)
2. Nuclear Weapon Delivery (A-6A)
3. Mine Laying (A-6A)
4. Electronic Warfare Operations (EA-6A)
5. Electronic Reconnaissance/Intelligence (EA-6B)

For all of the various missions and models of aircraft, the most demanding and significant requirements in terms of life support/protective equipment are associated with the A-6E all weather day/night attack mission with conventional ordnance. In essence, this mission represents the typical case situation.

MISSION PROFILE SUMMARY (See Figure 5)

For purposes of security and simplicity, the A-6E Mission Profile (attack mission) has been abbreviated to outline form. The listed speed and altitudes may vary accordingly to mission assignments, threat levels, and environmental conditions.

The at-sea mission time for the A-6E is normally 3 to 3 1/2 hours. With an in-flight refueling the mission time can be extended up to a maximum of 5 hours.

CREW COMPOSITION AND FUNCTION

The A-6E aircraft has a two man crew consisting of a Pilot and a Bombardier/Navigator (BN). The duties of the Pilot/Bombardier/Navigator team are necessarily integrated and each must support and contribute to the overall performance of the other.

The Pilot is the aircraft commander and is responsible for the safe operation and control of the aircraft throughout its entire mission.

The Bombardier/Navigator is responsible for determining the most optimum approach to and from the target area as well as the most accurate delivery of the weapons/ordnance carried by the aircraft.

For both men, the tasks performed throughout the mission are in the nature of small precision movements aimed at effecting adjustments in the flight controls and numerous electronic equipment such as navigation computers, radars, and weapon control release panels. All of these tasks require a high degree of intellective judgment and coordination. Although there are no major gross

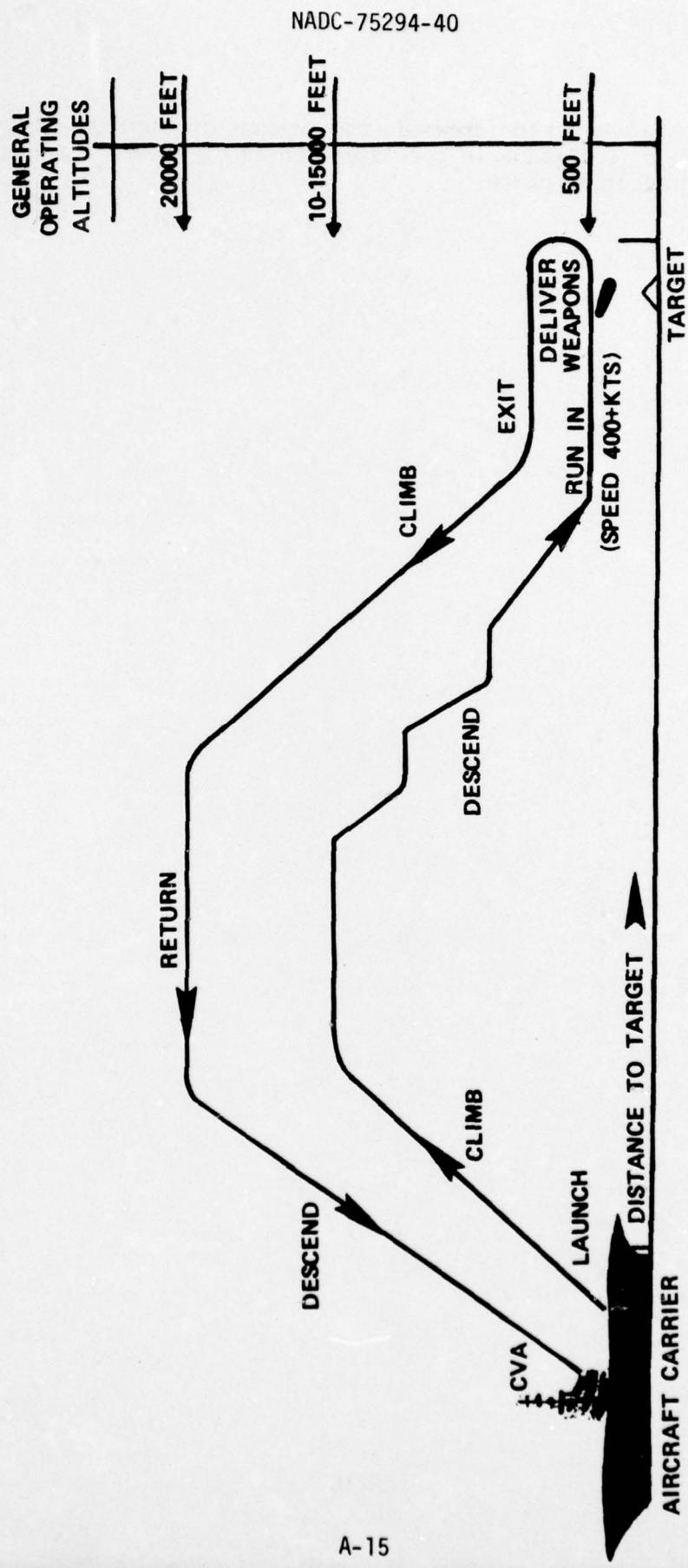


Figure 5. A-6 Mission Profile.
Attack Mission.

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physical tasks required of the crewman, the demands of the mission for precision do give rise to fatigue in the later period of the mission profile, i.e., the return/recovery phase.

A-7 SERIES AIRCRAFT

U.S. NAVY DESIGNATION: A-7 and YA-7H

INTRODUCTION

The basic A-7 aircraft is manufactured for the Navy by Ling Temco-Vought (LTV) Corporation. The Navy has retained the manufacturer's designation of "Corsair II". The aircraft was based on an earlier design study of the F-8 Crusader.

The A-7 is a single-seat carrier-based light attack aircraft. It is subsonic with a larger ordnance carrying capacity than the A-4E. Currently, the U.S. Navy operates several variations of the basic A-7 airframe which are summarized as follows:

A-7A (Corsair)

This was the initial aircraft for the Navy with a 11,300 lb. thrust engine. It entered service in Vietnam in 1967.

A-7B (Corsair)

This is an improved version of the A-7 with a 12,200 lb. thrust engine which entered service in Vietnam in 1969.

A-7C (Corsair)

Designation given in 1971 to the first 67 A-7E's to eliminate confusion with subsequent Allison engine powered A-7E's.

A-7E (Corsair)

This is an improved version for the Navy with an Allison 15,000 lb. thrust engine. It was employed as a light attack close air support/interdiction aircraft. The aircraft entered service in Vietnam in 1970.

YA-7H (Corsair)

This is a single prototype of a two-seat version with potential as an advanced trainer or for tactical operations. The basic airframe is the A-7E.

SUMMARY OF TACTICAL MISSIONS

The A-7 aircraft mission capabilities are evidenced by the following tactical capabilities:

1. Light Attack Mission (A-7A, B, C)
2. Light Attack, Close Air Support Interdiction (A-7E)
3. Advanced Trainer Aircraft (Prototype Only) YA-7H
4. Inflight Tanker/Refueling A/C (Special Conversions Only)

For all of these missions and models, probably the most demanding and hazardous mission is that of Attack, Close Air Support/Interdiction due to the fact that the aircraft would enter the probable envelope of enemy ground (or air) weapons while conducting its mission. In essence, this mission (A-7E) represents the worst case situation.

MISSION PROFILE SUMMARY (See Figure 6)

For purposes of security and simplicity, the A-7E mission profile has been abbreviated to outline form. The listed speeds and altitudes can and do vary according to the mission assignments, threat levels, and environmental conditions.

The normal at-sea mission time for the A-7E is 1 1/2 to 2 1/2 hours with additional time extended if a mission recycle, land, refuel, takeoff, is required.

CREW COMPOSITION AND FUNCTION

The A-7 aircraft is a single seat aircraft whose pilot performs the dual function of flying the aircraft and delivering the weapons/ordnance on the designated targets.

The sophistication of the air/weapons system is reported to impose peak demands for skill, coordination and intellective judgment on the pilot. Although these tasks/functions are limited only to precision equipment operation and adjustment, a high skill level and task loading is imposed on the pilot. This in turn induces premature fatigue in the pilot, with attendant degradation of performance in the combat portion of the mission profile.

The limited cockpit size of the aircraft is also restrictive to the movements of a large aviator which contributes to discomfort and fatigue.

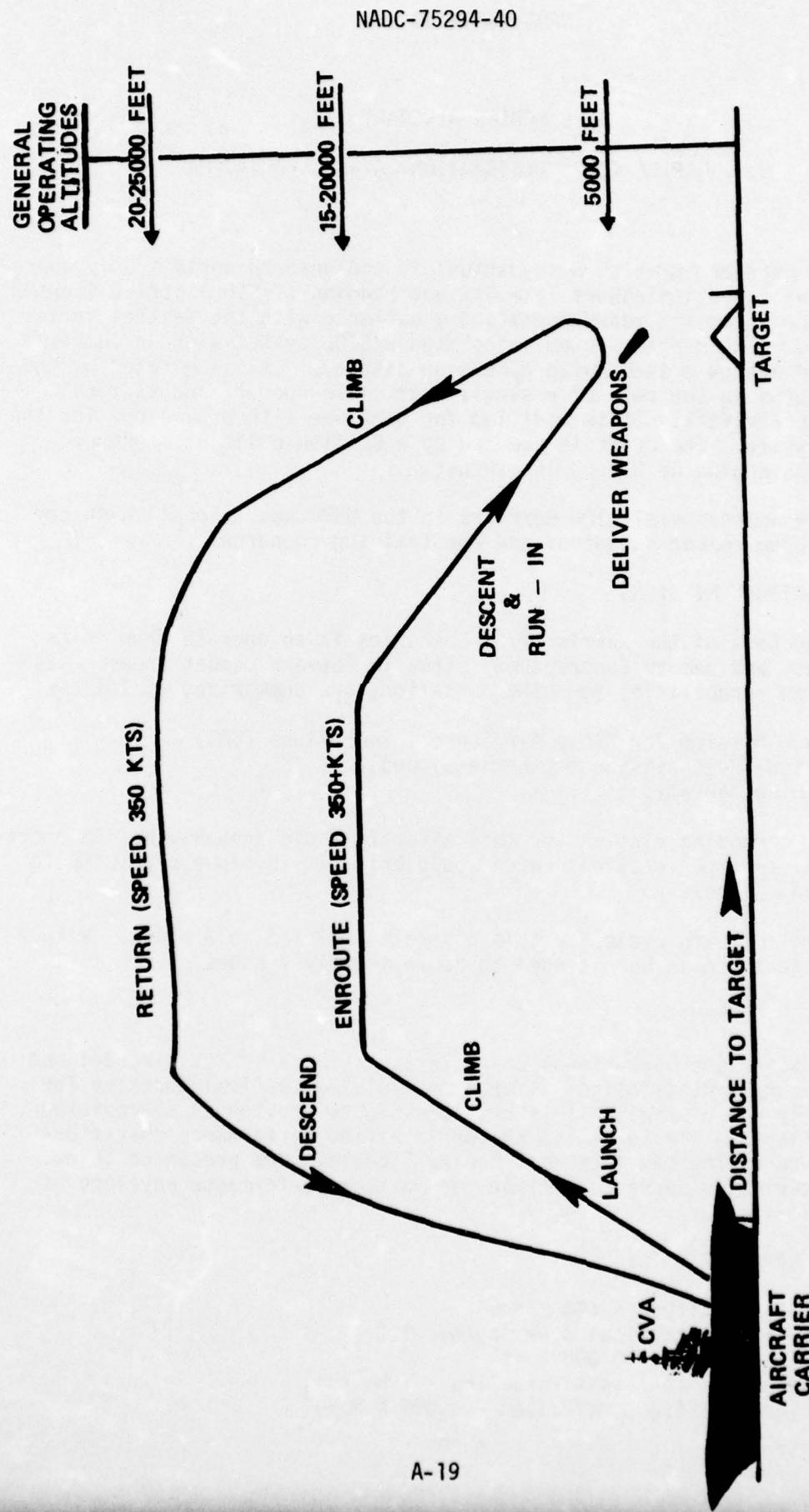


Figure 6. A-7 Mission Profile.
Attack Mission.

AV-8 SERIES AIRCRAFT

U.S. MARINE CORPS DESIGNATION: AV-8A and TAV-8A

INTRODUCTION

The AV-8 Harrier (British Designation) is the western world's only operational fixed-wing Vertical/Short Take Off and Landing (V/STOL) strike fighter. It was developed from six years operating experience with the Kestrel series flying machine. The Harrier is an integrated V/STOL system with an inertial navigation and attack system, with a head-up display. It is operated by the U.S. Marine Corps in the role of a single-seat close support and tactical reconnaissance aircraft. It is modified for USMC use with provisions for the Sidewinder Missile. The craft is powered by a British-built Rolls-Royce Bristol Pegasus engine of 21,500 lb. thrust.

There are approximately 100 Harriers in the USMC operational inventory which equip three combat squadrons and one training squadron.

SUMMARY OF TACTICAL MISSIONS

The uniqueness of the Harrier V/STOL enables it to operate from ships, land air bases, and remote (unprepared) sites in forward combat areas. Its current mission capabilities for USMC operations are summarized as follows:

1. Attack Mission for Close Air Support Operations (CAS)
2. Tactical Reconnaissance (when equipped)
3. Training operations

The most demanding mission for this aircraft would probably be CAS operations from remote site locations which would bring it in close proximity to enemy fire and weapons.

The normal mission cycle for this aircraft is 2 1/2 to 3 hours. With a refueling cycle it could be extended to approximately 7 hours.

MISSION PROFILE SUMMARY

Due to its unique operational characteristics as a V/STOL aircraft and prevailing security restrictions as well as evolving tactical doctrine for this relatively new aircraft, it is not possible to provide an abbreviated mission profile. In view of this, the unclassified performance characteristics as given by the manufacturer, Hawker Siddeley, are presented below. These characteristics serve to outline the maximum performance envelope of this versatile aircraft.

PERFORMANCE CHARACTERISTICS

Speed at Low Altitude - 640 knots+
Mach Number in a tactical dive-approx. 1.3
Ceiling-In excess of 50,000 feet
Endurance - (one in-flight refueling - 7 hours+)
Range - (one in-flight refueling - 3,000 N.M.+)

CREW COMPOSITION AND FUNCTION

This is a single seat, pilot-only aircraft who performs the dual functions of flying the aircraft and delivering the weapons/ordnance on the designated targets.

The V/STOL characteristics of this aircraft are uniquely different than any other jet powered high performance tactical aircraft. This makes the task performance more difficult than usual. Accordingly, the AV-8 demands a high degree of pilot motor skill and intellective judgments. In a combat environment the combination is highly fatiguing and demanding on the pilot which produces attendant degradation in sustained performance.

S-3 SERIES AIRCRAFT

U.S. NAVY DESIGNATION: S-3A

INTRODUCTION

The S-3A aircraft is manufactured for the Navy by the Lockheed Aircraft Corporation which functioned as the prime contractor. The S-3A was designed as a carrier-based Anti-Submarine Warfare (ASW) aircraft with the mission of locating and attacking enemy submarines which could threaten a surface fleet or task force.

The S-3A aircraft entered fleet service in 1974. It is a highly sophisticated and automated aircraft, incorporating the latest operational technology available. The performance characteristics of the S-3A will make possible future design variants of the basic "Viking" platform. This includes tanker, utility transport, ASW command and control and a variety of electronic countermeasures aircraft. It is powered by two GE jet engines of 9,275 lbs. thrust each.

SUMMARY OF TACTICAL MISSIONS

The S-3A is currently employed in only its primary design mission of ASW search and surveillance from sea based (CV) platforms.

MISSION PROFILE SUMMARY

The sensitive and critical nature of the ASW problem prevents the presentation of an abbreviated mission profile. However, for purposes of illustration, all ASW missions have the following basic phases in common:

1. Search. The aircraft is launched to a given area or sector where it conducts an active or passive sensor search, in a prescribed tactical pattern, for any submarines in the area.
2. Detection. When a contact is gained by one of the sensors, it is analyzed to determine its significance and validity prior to the next phase.
3. Identification. In this phase further information and analysis is brought to bear on the contact to determine its origin and identify it for the next phase.
4. Localization. In this phase, coordinated tactical efforts are aimed at narrowing the probable location of the contact. Multiple sensors are employed to bring the aircraft within the launch envelope of its weapons.
5. Kill. In this phase the aircraft commences weapon(s) launch on the localized target to destroy it or deny its mission (peacetime).

In order to round out the picture of the tactical capabilities of the S-3A aircraft, the following performance envelope data is presented from the manufacturer's information base.

PERFORMANCE CHARACTERISTICS

Maximum Level Speed - 400 knots
Maximum Cruising Speed - over 350 knots
Loiter Speed - 160 knots
Service Ceiling - above 35,000 ft.
Combat Range - in excess of 2,000 N.M.
Ferry Range - in excess of 3,000 N.M.

CREW COMPOSITION AND FUNCTIONS

The S-3A comprises a four-man crew as follows:

1. Pilot. He is the mission commander and maintains command of the aircraft during the mission.
2. Co-Pilot. He is the alternate to the pilot and in addition, he is responsible for operating and monitoring the non-acoustic sensors (such as infrared and radar). He also navigates the aircraft.
3. Tactical Coordinator (TACO). He formulates strategy and guides the pilot for the necessary maneuvers and tactics against the submarine.
4. Sensor Operator (SENSO). He operates and monitors the acoustic sensors, i.e., the Sonobuoys.

The duties of all four men, though diverse in nature, have the functions of small precision adjustments on the complex avionics systems in common. This calls for a high degree of training, skill and intellective judgments.

The cumulative effects of fatigue are felt most prominently after sustained flight times on station which can often be in excess of four hours with attendant degradation of performance. However, this is somewhat offset by the high degree of automated systems which reduce the work load rate on the man.